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Geotectonics of the middle part of Polish Carpathians as a picture of 3-D Euler deconvolution of gravity anomaly

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Abstract. In the paper a system of gravity data interpretation not commonly used in Poland is presented – 3D Euler deconvolution. The method is based on Euler equation and allows us to determine depth and location, in x,y,z co-ordinates, of mass contacts that differ in density, fault zones, etc., and thus it is efficient to solve tectonic problems.

The results of conducted calculations of Euler deconvolution are presented for various cases of field parameters and anomaly bodies and to confirm the method efficiency they are compared with results of other interpretation methods. The empirical investigations have been restricted to an area of middle part of Polish Flysch Carpathians that is considered by the authors as interesting from the point of view of hydrocarbon deposit occurrence.

Key words: Carpathian flysch & basement, gravity interpretation, Euler deconvolution, Laplace filtering, band-pass filtering.

Method description

Three-dimensional Euler deconvolution is a method of interpretation of magnetic and gravity data to obtain location of density boundaries in x,y,z co-ordinates system. Its theoretical basis is Euler´s equation:

$$x\frac{\delta f}{\delta x} + y\frac{\delta f}{\delta y} + z\frac{\delta f}{\delta z} = n$$

where:

f (x,y,z) – a three-dimensional homogeneous function of n-th degree, satisfying the expression:
$f(tx,ty,tz) = t^n f(x,y,z)$

Considering a potential field, Euler´s equation can be presented as follows:

$$(x-x_o)\frac{\delta T}{\delta x} + (y-y_o)\frac{\delta T}{\delta y} + (z-z_o)\frac{\delta T}{\delta z} = N(B - T)$$

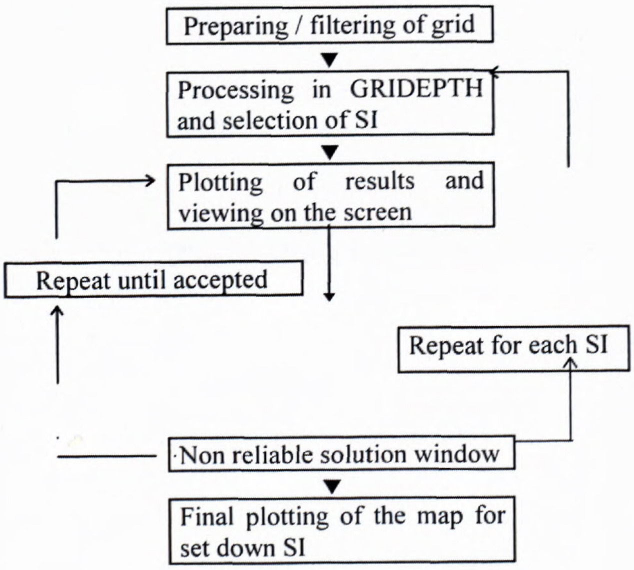
where:

x_o, y_o, z_o - co-ordinates of a disturbing source;
T – total field recorded in point x,y,z;
B – regional field value;
N – degree of inhomogeneity interpreted as structural index SI (N in this expression is equivalent of n in Euler equation).

The practical application of above-mentioned relation was worked out by Reid et al. [4]. It is available in GRIDEPTH firm GEOSOFT Inc. Toronto. The calculations are carried out using minimum square method on grid files of a unit cell size s, and also set up window of selected size (from 3x3s to 20x20s). Choosing a bigger window size information from bigger depth is gathered. Such procedure brings a risk to record anomalies caused by several disturbing bodies, thus obtained results will be not reliable and calculation gradients will not refer real gradients of one body. Thus it is better to use smaller windows and remove disturbing anomalies from the considered field.

The next control parameter of interpretation is the structural index SI determining the rate of field intensity changes in relation with the distance from source. For example in the case of gravity field a cylinder has index 1; a sphere 2, and in the case of magnetic field the sphere has index 3 and the cylinder 2.

A scheme of data processing procedure to select structural index SI



The next parameter important for the final result is so called result selection level in percents. It governs quan-

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tity of obtained information against its reliability. Generally it depends on data quality. Assuming a high selection level the results may be more reliable but in some considerations the disturbing body could be poorly outlined. Assuming to low level it takes the risk of obtaining effects due to other unwelcome sources obscuring the final picture.

The results of conducted calculations are arranged and putted into depth ranges and finally they are presented as circles of diameters relating particular depths. Interesting from the point of view of interpretation are solutions distributed in compacted zones. They make so called Euler lines determining disturbed body outlines or variable mass density contrasts. The effectiveness of the method depends directly on proper selection of control parameters. Thus satisfactory results can be obtained after performing calculations for various options of parameters adjusted to particular geological conditions.

Qualitative-quantitative interpretation of gravity anomalies

The aim of conducted qualitative-quantitative interpretation was determining the origin of recorded anomaly picture of potential fields and connecting them with inhomogeneities in flysch as relief of Mezo-Palaeozoic-Precambrian basement.

Previous interpretation works, conducted in qualitative approach, have not evaluated univocally local anomaly fields directly with the flysch's basement. A large impact on this has brought the picture of measured gravity field presented as gravity Bouguer anomaly. The observed picture is a superposition of not only fields of possible origin within the flysch and its straightforward basement but also a regional field. The regional contribution is mainly the "gravity minimum" and "Moho discontinuity" effect. Due to these facts authors have used OASIS [1, 2] package to obtain optimal results and a series of filters from this package to remove unwelcome effects (i.e. regional contribution). In the first stage a filtering on the base of Laplace formula has been applied . It has allowed us to separate contributions of shallow located anomaly sources from observed field to evaluate flysch's inhomogeneities, especially in a border zone of Carpathians. Alternatively band-pass filtering has a been applied. The choice of filtering parameters has to outlined deeper elements – connected with deep flysch in "gravity minimum" area and its basement in the border zone of Carpathians.

By interpretation, descripted above, Euler deconvolution has been. It has determined (in a quantitative approach) the character of recorded fields, generated by flysch and its basement, especially in the case of tectonic disturbed zones. For the interpretation works, after many tests, the models of thin layer and vertical step has been taken to search solutions for bodies within flysch, and vertical cylinder for the basement. The best effectiveness of the method has been obtained for a window of 15x15s for flysch and 20x20s for its basement. Using the trial approach and previous experiences the selection level has been set down to 15%. The taken parameters by authors opinion-reflect optimally the geological structure of the studied area.

The obtained course of Euler lines has been presented on the background of tectonic map of central part of Polish flysch Carpathians [3] for a level of 1000 m b.s.l. and 5000 m b.s.l.

Conclusions

As a result of conducted interpretation, authors have obtained quantitative approach to:

- Confirming the main tectonic zones in flysch and its basement;
- Distinct outlining the front of Śląska, Podśląska and Magurska nappes;
- Determining the range and depth of main positive anomaly zones recorded in flysch's basement.

The above mentioned result enriches knowledge on geological structure of this part of Carpathians. This allows us to prefer techniques proposed in the paper to solve other geological problems especially in the case of tectonics detection. For other structural solutions, further methods of elaboration are necessary.

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